Laboratory Manual for General Science

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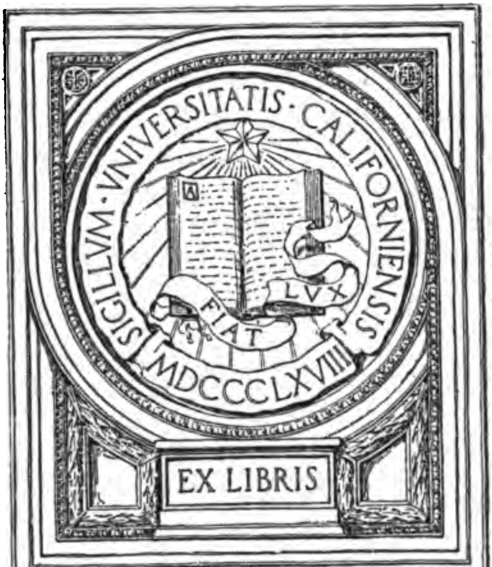
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LABORATORY MANUAL

FOR

GENERAL SCIENCE

FIRST COURSE

BY

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PREFACE

THIS manual has been prepared to meet the needs of those using or intending to use my *General Science*, First Course. The subject may be successfully taught without a laboratory manual or even without an equipped laboratory; but teachers and students who have a laboratory (the laboratory at school, the home, and the community) at their command will find suggestive assistance in this manual. The textbook and manual have been prepared with the view of giving young students a broad acquaintance with their environment and as complete a scientific explanation as their experience will permit, and we hope that such a training will lead to a successful adaptation to the environment.

The experimental exercises fall into three groups: (1) demonstrations by the teacher, (2) demonstrations by the teacher assisted by the students or by a few selected students, and (3) individual experiments, some of which are to be done in the school laboratory and the others at home and in the field observing natural phenomena. If there are five class periods per week, the author would suggest that two experimental exercises per week are enough for high school freshmen. The extra number of exercises make possible the privilege of selection. Some of the exercises may be of more interest to girls and others of more interest to boys.

The author hopes that this manual will be used for the best interest of those concerned and make of boys and girls healthy, vigorous, able, and successful persons in their efforts at complete living.

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LABORATORY MANUAL IN GENERAL SCIENCE

EXERCISE 1

INFLUENCE OF HEALTH

MAKE a record of the dates, names, and causes of all the diseases which you have had. Could these have been avoided or prevented? Who was to blame for them? Did you feel like working when you were sick?

Compare the records of students who have to stay out of school often for sickness with the records of those who are regular in attendance.

What effect does your father's sickness have on your home? Does his income continue? Why? Is a home as pleasant when the parents or the children are sick? Figure the money cost of the last two sick spells in your home. (See § 2, page 5 in the text.)

Was your whole community ever affected by sickness — an epidemic? Could cleanliness and carefulness have avoided much or all of it? Why? Make a record of what your community officials do to prevent sickness. Tell what more they should do. How can you help them?

What is your conclusion about the influence of health on your happiness and success? What can you

do to keep yourself, your home, your school, and your community in better health? Do you think it worth while to acquaint yourself with your environment (clothing, food, air, water, home, school, plants, animals, and weather) so that you will know how to keep in good health or to become healthy if you are not so now?

EXERCISE 2

DIVISION OF SUBSTANCES INTO SMALL PARTICLES

Rub a little water on your hand and move it through the air a few times. What becomes of the water? Did you see it go? Why? Do the same with a drop of alcohol, of gasoline, and of ether. How do some of these substances get to your nose?

Place a small quantity of sugar in some water and stir it. What became of the visible sugar? Taste the water. Try common salt in the same way. What is your conclusion as to the size of the parts of sugar and salt?

What is the name of these small particles of water, alcohol, sugar, and salt? (See § 9, page 10 in the text.)

Why can water be poured from a vessel easier than sugar or salt?

EXERCISE 3

ACIDS, BASES, AND NEUTRAL SUBSTANCES

Divide a sheet of paper into three columns and at the head of the columns write the words:

Acids	*Bases*	*Neutral Substances*

Then test the following substances with litmus paper, using both red and blue (see textbook for effect of these substances on litmus).

Water from a well or spigot.
Rain water.
Apple juice.
Lemon juice.
Household ammonia.
Alcohol.
Vinegar.
Milk.
Sour milk.
Baking soda dissolved in water.
Cream of tartar in water.
Baking powder in water.
Common salt in water.
Sugar in water.
Tomato juice.
Wet soap.
Cleaning powders in water.

Write the names of the substances which turn blue litmus to red in the acid column, those which turn red litmus to blue in the base column, and those which do not affect red or blue litmus in the neutral column. (Sometimes a few minutes are necessary to change the color of the litmus.) Taste the substances whose names are in the acid and base columns. How do they compare?

Neutral Substances. — Dissolve two teaspoonfuls of cream of tartar in one-half cup of water and taste it. Dissolve one teaspoonful of baking soda in one-half cup of water and taste. Now slowly pour one solution into the other. After it stops bubbling taste the solution. Put in red litmus paper and then blue litmus paper and note the effect.

Now dissolve a teaspoonful of baking powder in half a cup of water. Taste the solution and test it with litmus. How does it compare with the baking soda and cream of tartar mixture?

To form a neutral substance of ammonia and vinegar, or of caustic soda and hydrochloric acid, follow the directions in the textbook, page 15.

If you should spill some strong acid on your body or on the floor, what would you put on it? Why? If you should spill a strong base, what would you put on it?

EXERCISE 4

MAKING SOAP

Apparatus and Material. — Small iron cooking utensil or tin can, stove or gas burner, tablespoon or scales, potash from grocery or sodium hydroxide, lard or other fat, water, and common salt.

Dissolve one spoonful of potash in ten spoonfuls of water in the small cooking utensils or tin can. Add about one-half a spoonful of lard or other fat. Place this mixture on the fire and boil very slowly for about thirty minutes. Place a few drops of it in a cup of cold water and stir. If globules of grease appear on the water, the soap is not fully cooked. Cook and test until no grease appears on the water used in testing. If it boils away too much, add a spoonful of water occasionally.

When the soap is well cooked, place a spoonful of it in a cup and set aside. To the remaining part, while still cooking, add slowly a spoonful of common salt. After five minutes remove it from the fire and let it stand until cold. Carefully remove and save the whitish substance on the top. Use a small portion of this to wash your hands and try to make a lather.

Now try to make a lather with a small part of the soap in the cup. Is the soap in the cup hard or soft? Why? (See § 14, page 16 in the text).

Test the two soaps with litmus paper. Is soap a base, an acid, or a neutral substance?

Place a few drops of olive oil, castor oil, or melted lard in a cup or test tube and add a little warm, soft

ater, and stir. Does the water mix with the fat? Now add a few drops of ammonia or lye and stir again. Note the effect of the base. This solution is called an emulsion.

Are soaps basic? Test with litmus.

Your hands and face are kept soft by an oil secreted by glands in the skin. (See text, page 17.) What kind of substance is necessary to remove this oil? To make sure of this, rub a little oil on your hands and try to wash it off with vinegar or other very dilute common acid.

EXERCISE 5

[*Demonstration, assisted by students*]

HOW TO DETERMINE WHEN WATER IS HARD AND HOW TO SOFTEN IT

Apparatus and Material. — Three test tubes, rain water, well or hydrant water, soap, washing soda (Na_2CO_3), calcium sulphate solution or sulphuric acid.

Fill two test tubes half full of rain water Put about the same quantity of well or hydrant water into the third test tube. Now place a small piece of good soap in each tube and shake briskly a few seconds. If a white lather is formed the water is soft. If a dirty, gummy substance appears on top of the water, the water is hard.

Place a few drops of calcium sulphate or a drop of dilute sulphuric acid (or hydrochloric acid) in one of the tubes which you think contains soft water and shake for a few seconds. What has happened to the lather? What kind of water is it now?

Now add some washing soda to the water in the tube which you found to contain hard water and shake again. What has happened? What kind of water is it now?

For Students to do. — Can you wash grease from clothing or from your hands with hard water and soap? Prove it by an experiment and record the results.

Find out whether soap or washing soda is cheaper for softening hard water.

EXERCISE 6

[*To be done at home*]

HOW TO COOK POTATOES

Apparatus and Material. — Ten small potatoes, a hot oven, a two-quart saucepan, water.

Potatoes are a valuable food and are one of the staple articles in the diet of the American people. It is very important to know how to cook them so that they can be easily digested.

Thoroughly wash eight good potatoes about the size of eggs. Place four of them in an oven hot enough for baking bread. Put the other four in a cooking utensil containing a quart or more of water, either hot or cold, and place them on a fire that will make the water boil violently for forty minutes. Note the time when the water begins to boil and also the time when the potatoes were placed in the oven. After twenty minutes of baking remove a potato to see if it is cooked enough to eat. Do the same with

one of the potatoes that has boiled for twenty minutes. (If it can be mashed with a fork and is dry, white, and mealy, it is through cooking or baking. This test is to be made within three minutes after removing from the fire.) After thirty minutes take another potato from the boiling water and one from the oven and test. Compare with the first test.

After forty minutes remove the remaining potatoes and test a boiled one and a baked one. Compare with the other two tests. In which of the three tests are the potatoes in the best condition?

Ten or fifteen minutes after the last ones were removed, test the remaining two. Are they dry, white, and mealy as they should be? What has happened? Judging from this, how soon should potatoes be served after being taken from the fire?

Now cook two potatoes in water which is not quite hot enough to boil. At the end of forty minutes try one. Compare with those cooked in boiling water. What difference do you find? At the end of fifty minutes try the other one and compare. Why are potatoes when cooked in violently boiling water better than when they are cooked in water just about boiling?

EXERCISE 7

[*To be done at home*]

TESTING WHEAT FOR GLUTEN

Apparatus and Material. — Teaspoonful of clean wheat grains, tablespoonful of flour, piece of cotton cloth, string.

Place the wheat grains in your mouth and chew them for about ten minutes without attempting to swallow, much the same as chewing gum is chewed. Examine the gray, gummy substance left in the mouth. It is gluten.

Place the flour on a good piece of cotton cloth. Pull the corners of the cloth together and tie a string very tightly just back of the flour to keep the flour in place. Now make it thoroughly wet and squeeze it between the fingers for about fifteen minutes. Dip it in water often while working with it. The white substance which comes through the cloth and is washed away is mostly starch. After the flour has decreased about one-third its original size and no more starch comes through the cloth, open and examine. How does this substance compare with that obtained by chewing wheat?

EXERCISE 8

[*To be done at home*]

BAKING CHEMICALS

Bake one biscuit under each of the following conditions. (Be sure to mark each one so you can tell what was used in each.)

1. By using baking soda, flour, salt, and water or sweet milk.
2. By using baking soda, flour, salt, water, and sour milk.
3. By using baking soda, flour, salt, water, and a few drops of vinegar.

4. By using baking powder, flour, salt, water, and a few drops of vinegar.

5. By using baking powder, flour, salt, water, and sweet milk.

6. By dissolving the baking powder in water and then mixing it with the flour and salt.

7. By using flour, salt, and water or milk without any baking chemical.

Examine the seven biscuits and explain why they are different. If you wanted to bake some for the table, which combination would be best? (Take your biscuits to class to be compared with the results secured by other students.)

Take a sample of your baking powder to school to be tested for alum.

EXERCISE 9

[*Demonstration*]

TESTING BAKING POWDER FOR ALUM

Apparatus and Material. — Bunsen burner, ring stand, wire gauze, filter papers, funnel, porcelain dish, samples of baking powder, including some of the cheapest and best on the market, and an alum compound in powdered form.

Burn a few grams of the powder to be tested in the porcelain dish, mix the ash with boiling water, and filter. Add to the filtrate enough ammonium chloride solution so that the mixture will have a distinct odor of ammonia. Look for white flakes in the solution. If none appear at once, warm the solution slowly.

These white flakes, if any, are composed of an alum compound and indicate the presence of alum in the baking powder.

If a baking powder containing alum cannot be found, mix a few grains of the alum compound with some baking powder and then test for alum in order to show the alum test.

EXERCISE 10

[*To be done at home*]

EFFECT OF HEAT ON BACTERIA

Apparatus and Material. — Two small bottles (about one-fourth pint capacity), two corks, one-half pint milk.

Sterilize the bottles by washing them in boiling water and turn them upside down so the water can drain out. Fill one with sweet milk that has been heated to the boiling point. Fill the other with raw sweet milk. Sterilize the corks by dipping them into boiling water and place them in the two bottles loosely. Label the bottles "Boiled Milk" and "Raw Milk" respectively

Keep them at living-room temperature for two or more days to see which one sours first and record the time necessary for each to sour.

Explain why the one required a longer time than the other. Why do city boards of health require milk to be pasteurized? How is heat used in preserving foods?

EXERCISE 11

[*Demonstration*]

EFFECT OF SOME CHEMICALS ON BACTERIA

Apparatus and Material. — Three test tubes, one-half pint raw milk, small amount of formalin, alcohol, and powdered sodium sulphite (Na_2SO_3), small piece of fresh beef that has a dark color and a slight odor of decay.

Fill the test tubes half full of milk. To one add a drop of formalin; to another add a drop of alcohol. Do not add anything to the third. Cork them loosely and label each according to the chemical added. Set them away at room temperature for two days or more.

Have the students record the process and the results.

Sprinkle the beef with the powdered sodium sulphite, or dip the meat into a solution of sodium sulphite. After a few hours observe the effect on the color and odor.

The sodium sulphite stops the decay but does not remove the poisons already formed, and it is not a good compound to be taken with food.

Other examples of chemical treatment to prevent decay are: wood paving blocks and railroad cross-ties boiled in creosote; laboratory specimens preserved in alcohol or formalin; cured meats preserved by common salt and smoke. (Spices are often added.)

What is the danger of eating foods preserved in dangerous chemicals such as formalin, sodium sulphite, etc.?

EXERCISE 12

EXAMINATION AND COMPARISON OF PATENT MEDICINE ADVERTISEMENTS AND DESCRIPTIONS ON LABELS OF BOTTLES

From newspapers, magazines, and publications of various kinds collect a number of patent medicine advertisements and quick cures. Read them carefully and discover how the language is arranged and worded to catch the average reader and make him believe that he has the disease which the medicine is designed to cure. (Be sure that you yourself do not get that impression.)

Notice carefully the medicines advertised for children. Do the advertisements tell of what the medicines are made?

Take some patent medicine bottles from your home, or examine some in a drug store and read the labels carefully. Do they tell the per cent of narcotics in the medicine? Are these harmless?

Compare the labels on the bottles with the advertisements. Do the advertisements tell the truth about the danger of the contents of the bottles?

EXERCISE 13

[*Demonstration*]

PREPARATION OF OXYGEN AND ITS PROPERTIES

Apparatus and Material. — See text, page 48. Oxygen can be prepared in a wide-mouthed bottle covered with a cardboard or glass cover while chemical action is taking place between the following chem-

icals: place in the bottle about four cubic centimeters of potassium permanganate or manganese dioxide and add slowly a few c.c. of hydrogen peroxide through a tube reaching to the bottom of the bottle. The oxygen formed will force the air out of the bottle.

Collect several small bottles of pure oxygen. Determine how it acts on a burning splint of wood. Have pupils smell it, after it is washed.

Is oxygen heavier or lighter than air? How much of the air is oxygen? (See § 33 in text.)

Why are stoves made so that air can enter the fire-box? Why do you take air into your lungs?

What is the source of oxygen needed to burn enclosed gunpowder or dynamite?

EXERCISE 14

[*Demonstration*]

KINDLING POINT OF SOME SUBSTANCES

See text, pages 50–51

Apparatus and Material. — Very small piece of yellow phosphorus, a cork float, piece of blotting paper, small piece of iron, various kinds of matches, two sheets of good writing paper.

Place the piece of yellow phosphorus on the cork float and put the float on water. (Be careful not to handle the phosphorus with your fingers. Use the blotting paper to place it in position.) Now hold the piece of iron in your hand until it is warm, then hold it against the phosphorus for a few seconds, provided the phosphorus has not ignited in the meantime. (Phosphorus will ignite in a draft of dry warm air.)

Ignite various kinds of matches by friction to show that their kindling point is low.

Why is phosphorus used in the manufacture of matches? What is the difference between a safety match and an ordinary match? Why is red phosphorus rather than yellow phosphorus used in the manufacture of matches? Why is pine wood rather than oak used in making matches?

When making a coal fire why are paper or shavings, kindling, larger pieces of wood, and finally coal used respectively, and why is the coal placed on top?

Hold a burning match to the corner of a piece of writing paper. Observe that it turns dark and smokes before a blaze appears. What was happening? Observe the approximate time the match is held to the paper before it burns in a blaze.

Now hold the same kind of a burning match to the middle of the same kind of a sheet of paper. Compare the results with those obtained while holding the match to the corner. Explain.

If damp hay in a barn or rags in a shed catch fire suddenly, what has happened?

EXERCISE 15

EXAMINATION OF FORMS OF CARBON

Apparatus and Material. — Magnifying glasses, knives, carbon rods, charcoal, wood, coal, coke, diamond, electric light, electric cell, carbon poles, and graphite.

Examine some charcoal carefully with magnifiers, if you have them. Determine whether it is made

of wood or coal. If made of wood, of what kind? What kind of wood is used for making drawing charcoal?

Examine some coal and coke. Of what is coke made? How do coke and charcoal compare in hardness? For what are they used?

Examine some graphite (the part of a lead pencil with which you write). How does it compare with coke and charcoal? Is it made of wood or coal, or is it mined? Compare it with electric light carbon rods.

In what two ways do these forms of carbon differ from the diamond? What valuable use is made of the diamond besides that of jewelry?

If carbon is oxidized, what is formed?

EXERCISE 16

[*Demonstration by Students*]

PREPARING AND TESTING CARBON DIOXIDE

Apparatus and Material. — A few grams of marble, limestone, or blackboard crayon, water, few grams of hydrochloric acid, baking powder, baking soda, vinegar or other acid, a beaker.

Carbon dioxide can be made and collected with an apparatus like that shown in the text on page 56 or by use of a pneumatic trough as shown on page 48.

Put into the bottle a few grams of marble, limestone, or blackboard crayon. Cover this with water, being sure that the end of the thistle tube is in the water. When the apparatus is ready for collecting the gas, occasionally add a gram of hydrochloric or

sulphuric acid. (Hydrochloric acid is safer to use as it does not generate so much heat.)

Test a bottle full of the gas with a burning splint or match. Does it support combustion? Is it heavier than air? What is its color? Its odor?

Pour some water on baking powder and test the gas escaping with a burning splint or match. Of what use is this gas in baking? Place about one gram of baking soda in a beaker, add some water to dissolve it. Now add a few drops of vinegar or other acid.

Why is sour milk used with baking soda?

What chemicals may be used in a fire extinguisher? Why does it put out a fire so easily?

Is it safe to breathe carbon dioxide? Why? Is it safe to drink carbon dioxide? Why? Does it have any commercial value for drinking purposes? What are the dangers in the use of such drinks?

Name all the ways in which carbon dioxide is formed at home.

EXERCISE 17

[*Demonstration by Students*]

TESTING BREATH FOR CARBON DIOXIDE

Apparatus and Material. — Unslaked lime, a deep bottle, several small bottles or large test tubes, a glass tube for each small bottle, water, carbon dioxide.

Prepare the limewater several days before this experiment is to be performed. To do so, put some

unslaked lime into a deep bottle about half full of water. (Use one gram of lime to three grams of water.) Shake it occasionally to dissolve the lime or to make it react with the water to form limewater (CaO_2H_2). When the lime is all slaked, fill the bottle with water and shake again. Set it away for a few days to let the undissolved lime settle. Then pour off and keep the colorless limewater for future use.

Pour colorless limewater into several small bottles or large test tubes. Force some carbon dioxide into one of them through a tube extending to the bottom of the limewater, and record the result.

Now place a glass tube in each of the other vessels containing limewater and let several students blow gently into them to form bubbles and watch for the water to turn white. Compare the result with that obtained with carbon dioxide. What gas does the air coming from your lungs contain? From where does this carbon dioxide in your breath come? Why do you breathe? What do you take out of the air when you breathe? Why should living rooms be ventilated?

EXERCISE 18

EXAMINATION OF VENTILATION OF SCHOOL AND HOME

Apparatus and Material. — Anemometer (wind gauge) or candle and matches.

If you breathe eighteen times per minute and take into your lungs 30 cubic inches of air at each breath, how much fresh air do you need per hour? How

much air is needed per hour for all of the people in the room?

While sitting in a room, is it dangerous to have a cool draft striking any part of the body? Is it dangerous to be in a draft of cool air out in the open? Explain.

Air moving three or more feet per second can usually be felt as a draft. How large an opening would be required for sufficient air to enter without a draft to supply all the students in the schoolroom?

With an anemometer or a burning candle determine the speed and direction of air currents in the schoolroom. (Make a drawing of the room and place arrows to indicate air movements. See text, pages 102–103.)

Determine by experiment which windows at school and at home should be kept open to give proper air movements for all parts of the rooms. When should windows be opened from the bottom? When from the top? Should the same windows always be kept open? Should windows be kept open the same amount all of the time? Why?

If a hot-air furnace is used, determine the volume of air entering your room per hour from the furnace. Is it sufficient? How would open windows affect the volume of air coming from the furnace? If windows are not opened, how will the furnace air get out of the room?

If you have steam or hot-water radiators or stoves in the room, how should windows be opened? Why are radiators placed near doors or windows?

How does good ventilation affect colds, pneumonia,

and other lung and throat troubles? How does ventilation affect the amount of work that you can do in school and at home?

EXERCISE 19

OBSERVATION OF THE THREE COMMON STATES OF MATTER

Apparatus and Material. — Glass or metal beaker, or other vessel, small piece of ice, scales.

Weigh a glass or metal beaker or other vessel. Place in it a small dry piece of ice and weigh again. How much does the ice weigh? Let the ice melt and weigh the beaker with the water from the ice. How much does the water weigh? Has anything been lost? (Matter was transformed but not destroyed. See text, page 65.)

Compare the water with the ice. Does it feel the same? Have the same shape? Have the same temperature? What must be added to ice to make it melt?

If you should let the water stand for a few days or should heat it to the boiling point, what would happen to it? If you could catch the vapor made from this water and weigh it, how would it compare with the weight of the water? Which fills more space, the water or the vapor from it? (See text, page 207.)

Name all of the ways in which steam differs from water and ice.

What other substances can be changed from the solid state to the liquid condition? Is mercury a solid or a liquid? When?

EXERCISE 20

EXPERIMENTS WITH GRAVITY

Apparatus and Material. — A heavy ball, a piece of string, scissors.

Suspend the ball by means of the string. Why does the ball take a position directly under the point where the string is attached above? Why is the string in a vertical position?

Without disturbing the ball, carefully cut the string with scissors. Why did the ball fall? In what direction did it fall? In what direction would the ball fall if you did the same thing at the north pole; at the equator; at the south pole?

Draw a circle representing two opposite meridians on the earth and indicate the direction in which a ball would fall in various positions on the earth. How does this compare with the way in which a magnet acts on an iron tack when the magnet is held in various positions with respect to the tack? When the magnet is placed close enough, does the tack always fall to it?

Why is it easier to stand erect than to lean over? With respect to the earth, how does a tree stand on the equator? Why?

Why does a ball, wagon, or automobile roll down a hill easily?

EXERCISE 21

EXAMINATION AND COMPARISON OF CENTIGRADE AND FAHRENHEIT THERMOMETERS

Apparatus and Material.—Fahrenheit thermometer, Centigrade thermometer.

Make a drawing of two thermometers and label them Centigrade and Fahrenheit respectively. (See text, page 74.)

Carefully examine the Fahrenheit thermometer and locate the principal temperatures of reference, as boiling point of water in an open vessel at sea level, the temperature of your body, living-room temperature in winter, freezing point of pure water, etc., and place them on your drawing in the proper positions. How many degrees does the space between each two lines represent?

Carefully examine the Centigrade thermometer and locate the same temperatures on it as you did on the Fahrenheit and place them on your drawing. (If they are not marked on the thermometer, find them by reducing the Fahrenheit temperatures to Centigrade readings.) How many degrees are represented by the space between each two lines on the Centigrade thermometer? Is it the same on all thermometers?

Should thermometers be placed in boiling water? How? What kind only? What substance is in the bulb?

EXERCISE 22

SOME EFFECTS PRODUCED BY HEAT

Apparatus and Material. — Use apparatuses similar to those on pages 80 and 81 of the text. Provide a metal ball and a metal ring through which the ball will just pass when both are cold.

On the basis of your past experience, make a list of all of the effects of heat that you have observed.

Prepare an apparatus similar to that shown in the text on page 80. Have the flask full of water and the water extending into the glass tube that reaches just through the rubber stopper. Do not have any air under the stopper. Place the flask on a wire gauze on the ring stand and support it with another ring at the top, if necessary. Measure the distance that the water stands above the cork.

Now place the lighted burner under the flask for a short time and observe what happens. Explain. How does this compare with a thermometer?

What is the danger, if a vessel entirely full of cold water is placed on the fire at home?

With an apparatus similar to that shown on page 81 in the text, determine how heat affects air. First hold the flask in both hands with the tube under water. Explain what happens.

Why is it dangerous to fill bicycle tires or automobile tires with cold air and then take them into the hot sunshine?

Heat the metal ball and see if it will pass through the ring. Explain. Now heat the ring to about the

same temperature as the ball and see if the ball will pass through. Explain.

How do blacksmiths use this property of metals? When are the spaces between the ends of railroad rails the greatest? Why do some steel bridges have a sliding roller under one end? Some arched steel bridges are highest in the middle in summer, some are lowest in summer. Explain.

EXERCISE 23

[*Demonstration by Students*]

DETERMINATION OF BOILING TEMPERATURE

Apparatus and Material. — A 500 c.c. flask, water, thermometer, Bunsen burner or other heat, 20 grams of sugar or salt, small amount of alcohol.

Fill the flask about half full of pure water and heat it to the boiling point with the top open. Slowly insert the thermometer. Do not let the thermometer touch the water. Hold it in position until the temperature remains constant, then read and record it. This is the temperature of boiling water in an open vessel at your altitude. Why is it less than 100° C.?

Now add to the boiling water about 20 grams of sugar or salt and take the temperature of the boiling solution. Explain the result.

Empty the flask and fill it about half full of a mixture of alcohol and water. Determine the boiling point of the solution. Explain the results.

If a mixture of alcohol and water is heated to 90° C., which will pass off by evaporation more rapidly?

Optional. — Try the experiment described on page 86 in the text.

EXERCISE 24

[*Demonstration*]

DISTILLATION

Apparatus and Material. — Set up an apparatus on the same principle as shown in the text, page 87. Patent medicine, or salt, sugar, or some colored substance may be used.

Put into the boiler some patent medicine to show whether it contains alcohol, as well as to illustrate the distilling process. If patent medicine cannot conveniently be had, put into the boiler some water containing salt, sugar, or some colored substance to show that distillation purifies water.

Have the students make a drawing of the apparatus as seen from their positions, also have them write an explanation of the process.

Have students make a list of substances which they use, that were made by distillation.

EXERCISE 25

[*Demonstration*]

COOLING BY EVAPORATION

Apparatus and Material. — Four bottles of convenient size, all of the same capacity and with necks large enough to insert a thermometer; four shallow vessels; eight accurate thermometers; water, alcohol, ether, and gasoline.

Fill the bottles almost full of these liquids respec-

tively, cork and leave them in the room under the same conditions so they will all have the temperature of the room. Place a thermometer in each bottle, with something around the thermometer where it enters the neck of the bottle to prevent the escape of any vapor.

Pour a small amount from each of the four bottles into the shallow open vessels, keeping each open vessel next to the bottle from which the liquid was poured, to avoid mistakes. Now place a thermometer in each of these open vessels. After a few minutes have students read and record the respective temperatures indicated by the thermometers in the bottles and in the open vessels. Have them explain what they see.

Have each student place a drop of alcohol or ether on the back of the hand and explain why it feels different from water.

What is the use of sweat on your body in summer? Why is the air cooler after a rain than before? Why is there more danger of catching a cold from partially wet clothing than from going bathing?

EXERCISE 26

MAKING ICE CREAM

Apparatus and Material. — 100 grams of finely crushed ice, 50 grams of common salt, a vessel which will not permit heat to pass through it readily, a thermometer. (Read Chapter XIII, p. 92 in the text.)

Make a drawing of a common ice cream freezer showing how it would appear if it were cut down

through the middle when ice, salt, and cream are in it. Label all the parts.

What is the use of the stirring apparatus inside the cream can? Why is the cream can made of metal and the outer wall of heavy wood?

What is the temperature of the ice when it is placed into the freezer? Would the cream freeze if the ice did not melt? Why? Salt is mixed with the cracked ice to melt it. How much heat is required to melt ice? From where does this heat come? If a mixture of salt and ice are continuously put into the freezer, what will happen to the cream?

Mix the ice and common salt in the vessel. Put the thermometer into the mixture and observe how low the temperature falls. How does the freezing point of a solution of salt and water compare with the freezing point of water?

EXERCISE 27

EXAMINATION OF HEATING SYSTEM AT HOME AND AT SCHOOL

Make a cross-section drawing of your school building showing the heating system. (Use the cuts in Chapter XIV as aids.)

Make a drawing of one room to show the movements of air to keep all parts heated.

How is ventilation provided for?

Make a similar drawing of your home to show the entire heating system used.

Now draw one room to show how it is kept heated in all parts.

How is ventilation provided for? Could your heating system be improved to save fuel and make the home more comfortable?

EXERCISE 28

MAKING A FIRELESS COOKER OR REFRIGERATOR

Apparatus and Material. — Two medium-sized boxes, one from two to four inches larger than the other; material to make a lid for the larger box; cork chips, sawdust, excelsior, or paper for packing; an article of food to be cooked; ten pounds of ice; a vessel which can be placed in the smaller box.

In the text on page 109 carefully examine the drawing of a fireless cooker and read the description.

Make the two boxes fit one into the other in such a way that two to four inches of space is left between the two boxes, including the top and bottom. Put the proper depth of packing in the bottom of the box and then set in the small box and fill in with packing on all sides. Now make a lid with the same thickness of packing in it. The cooker is now complete.

Make a drawing of your cooker.

Boil the food for about ten minutes and place it into the cooker to finish. Does the food get hotter or cooler in the cooker? Why does the heat not escape rapidly? Why is it better to have wooden boxes than metal boxes? Why is it better to use packing than the same thickness of solid wood? Why not leave the air space between without packing?

After the cooking vessel is removed from the cooker, leave the lid off for a while to let it cool. When it is

entirely cold, place the ice in a vessel, put it into the cooker and close the lid. Record the time. Every five or ten hours lift the lid just enough to see the ice. After the ice is melted record the time and find the number of hours necessary to melt the ice.

Explain how the cooker keeps the food hot and also keeps ice from melting. Why will ice wrapped in paper not melt so fast as when it is exposed to the air?

Examine your refrigerator at home and see if it is made on the same principle as the cooker.

Visit refrigerator cars, ice-houses, and cold storage plants to see how and of what they are made and how they are cooled.

EXERCISE 29

TESTING FOODS FOR STARCH, FAT, AND PROTEIN

Follow directions given on page 122 of the text.

EXERCISE 30

[*Demonstration*]

COMPOSITION OF WATER SHOWN BY THE OXIDATION OF HYDROGEN

Apparatus and Material. — Use apparatus and chemicals as indicated on page 135 of the text; use Hofmann apparatus also, if you have one.

Collect several large-mouthed bottles of hydrogen gas. Keep them closed with wet cover glasses.

Take the cover glass from one which is upright and at the same time hold one in your hand inverted with cover glass removed. After a minute or two hold a lighted match to the one which is upright and then to the inverted one. Have students give reasons for the results. Now remove cover from a third bottle and immediately apply a burning match.

After the hydrogen gas has been flowing from the generator for quite a while light the gas at the end of the tube. (**Caution.** — If any air is in the flask a serious explosion may result.) Hold over the burning hydrogen flame a large dry glass tube, test tube, or long-necked flask, and notice the drops of water collecting on the inside. What is the source of this water? Why will water not burn?

EXERCISE 31

WATER A SOLVENT AND SOIL CARRIER

Apparatus and Material. — Two glass vessels of equal weight, some common salt, cold water and hot water, baking soda, blue or green vitriol, alum, limestone, sulphuric or hydrochloric acid.

Put 25 grams of cold water into one of the glass vessels and 25 grams of hot water into the other vessel; add common salt to each as long as it will dissolve and not collect permanently on the bottom. Stir the water to make the salt dissolve more rapidly. When the two solutions are saturated, weigh them separately and determine how much salt was added to each. Does the hot water or the cold water carry the most salt in solution?

Try to dissolve the following substances in water: baking soda, blue or green vitriol, alum, limestone.

Also try the vitriol and alum in hot water. If the lime does not dissolve noticeably, add a few drops of sulphuric or hydrochloric acid. Record your results.

Examine your teakettle at home and see if any stony material has been left in it by evaporation of water. How are natural caves formed?

Just after a real hard rain get a quart of water from a small stream and let it stand a few hours to see how much mud collects at the bottom of the vessel. From where did this mud come? What made the gulleys on the hillsides? The valleys? How were the flat river bottoms formed?

EXERCISE 32

[*Demonstration*]

TESTING AIR FOR PER CENT OF NITROGEN AND OXYGEN

Apparatus and Material. — As shown on page 145 in the text.

Follow directions given on page 145 in the text, being careful that a draft of dry air does not strike the yellow phosphorus before it is in position on the prepared float.

EXERCISE 33

[*Demonstration*]

WEIGHING AIR

Apparatus and Material. — Football or basket-ball, pump for inflating it, balances accurate to the tenth of a gram; exhaust air pump and glass flask or bottle from which air can be pumped and excluded long enough to weigh empty bottle.

Follow directions given on pages 147 and 148 in the text.

EXERCISE 34

[*Demonstration*]

MEASURING AIR PRESSURE

To show one effect of air pressure, pump the air from a vessel as shown on page 149 in the text.

To measure the air pressure with mercury, follow the directions given on pages 149 and 150 in the text.

EXERCISE 35

EXAMINATION OF BAROMETERS AND HOW TO USE THEM

Make a drawing of the simple barometer shown you during the demonstration in Exercise 34.

Explain what held the mercury up in the tube.

Carefully examine the school mercurial barometer. Compare it with the simple barometer. What is the purpose of the mercury adjustment screw at the bottom, if any? Why is there a thermometer on it? Ask your teacher to show you how to read it. In what kind of units is it read? What do they mean? What does a barometer measure? How could you measure the height of a tall building or the height of a hill with a barometer?

Compare the mercurial barometer with the aneroid barometer. What is the use of the two hands on the aneroid? What moves them?

EXERCISE 36

FORMATION OF DEW

Apparatus and Material. — A piece of cold metal, teakettle of boiling water, a metal vessel, cracked ice, thermometer.

Hold, for just a second, a piece of cold metal in the steam coming from the spout of a teakettle. Or hold the metal just above some boiling water for a second. The drops of water on the metal are dew. The tiny

white fog seen just over boiling water, which is ordinarily called steam, is also dew floating in the air.

Put some water, about room temperature, into a metal vessel which is dry on the outside. Slowly add cracked ice and at the same time stir the water with a thermometer. Watch for moisture to collect on the outer surface of the vessel. Just as the moisture begins to appear, read the temperature of the water. That will be dew point or the temperature at which dew will collect on objects where you are.

Now add more ice and you will see the dew collect in large drops as it appears on the grass in the early morning.

Ask your teacher how to determine the dew point with a hygrometer.

When dew is formed in the air near the ground, what is it called?

Of what value is dew to vegetation or the growth of plants?

EXERCISE 37

EXAMINATION OF WEATHER MAPS

Material. — Blank weather maps, printed weather maps.

NOTE TO TEACHER. — Write to the Weather Bureau office at Washington, D.C., or to your local office for as many unprinted maps as you need — one for each student. Also the same number of printed maps, duplicates for one day. Your nearest Weather Bureau office will, upon application, send you the weather map daily if you will post it in a public place. Save these daily maps and use them in class at the same time that you use the duplicates.

Place the blank weather map and the printed weather map on your desk. From the data on the printed map draw the isotherms on the unprinted one, using dotted lines. Place the proper temperature at the ends of each line. What do isotherms indicate?

Now draw the isobars on the same map and place the proper numbers at the ends of the lines. What do these numbers indicate? What do isobars indicate? Write the words "high" and "low" in their proper places. In what direction does the wind generally blow in a "high" area? In a "low" area? What kind of weather follows each?

By observing the direction of the wind now, locate a "high" and "low" area. Tell what kind of weather you will have in 24 hours from now. How long does it take for a "high" or "low" to pass across the United States? Do they travel east or west? In what direction is the air moving in the center of a "high"? In the center of a "low"? Explain how this air movement affects rainfall.

What is the meaning of each kind of circle crossed by an arrow? What does the arrow indicate?

Observe how often the Weather Bureau's forecast comes true.

EXERCISE 38

[*Demonstration, assisted by all Students*]

COMPARE WEATHER BUREAU FORECASTS WITH ALMANAC FORECASTS

Material. — Daily weather maps running back several weeks or months; as many kinds of almanacs as the students can bring.

Select three Tuesdays in three weeks or three months and write the day and date at the head of three columns on the blackboard.

Write the Weather Bureau's forecast for each of those days at the top of each column respectively.

Now have the students find the forecast for those days in their almanacs and write in those three columns for the three days as many forecasts from the almanacs as there are different kinds of almanacs.

Have the students copy the three columns and compare the data which they contain. In how many cases do the almanacs agree?

Now make a fourth column for the day on which this lesson is given. Compare results. Are almanacs reliable for weather forecasts?

EXERCISE 39

MEASURING GAS PRESSURE

1. Demonstration with a simple Boyle's Law apparatus. (The simplest form is a U-shaped tube with one side much longer than the other, the long side being open at the end so that mercury can be poured in, and the short side closed at the end so that the air cannot escape when mercury is poured in the long side. This apparatus can be made by melting the end of a glass tube till it seals air-tight and then heat a short distance from the sealed end and bend to suit.) To use it, pour a small quantity of mercury into the tube and have it standing at the same height in each side of the U. The pressure of the air enclosed is then the same as the outside air pressure.

Now measure the length of the enclosed air column and then pour in mercury several times, making the mercury rise four centimeters each time in the open side; also measure the length of air column each time. Prove that $PV = P^1V^1$. (P^1 is the barometer reading plus the difference in level of the mercury in the two columns.)

2. Have students measure the gas pressure in automobile and bicycle tires. What must be done to increase the air pressure? To decrease the pressure? If you want to double the pressure in a tire, how much air must be put in?

Measure the pressure of the air in a football. Why is it necessary to have it pumped so full? Does the ball weigh more when full of air than when empty?

Is the gas pressure in a gas burner greater than the air pressure? Why?

When is the air pressure greatest in your lungs? When least? How would these two conditions affect the flow of blood into the lungs from the heart?

EXERCISE 40

VISITING AN ICE PLANT TO VERIFY LOSS OF HEAT DUE TO COMPRESSION OF A GAS AND AN INCREASE OF HEAT DUE TO EXPANSION AND EVAPORATION

After having read §§ 112 and 113 in the text, visit an artificial ice plant or cold-storage plant. Go to the compression pump and place your hand on the pipe through which the ammonia gas passes into the pump. What is its approximate temperature? Now

place your hand on the pipe which conducts ammonia gas from the pump. What is its temperature? (A thermometer may be used if more accurate results are desired.) What is the difference in the two temperatures? What is the cause of this difference? In which case is the heat being lost or given out, when the gas enters the pump or when it is leaving the pump?

Where does the ammonia gas go from the pump? What is being taken from the ammonia there? What is the use of cooling the ammonia? Is it a gas or a liquid after it is cooled?

Now go to the floor over the salt-water tank. (See picture in text on page 170.) Why is the floor made of small boards? How deep is the salt water? What is its temperature? (Test with a thermometer.) Why does it not freeze? At what temperature does the water in the iron tanks freeze? Then why is such a low temperature necessary for the salt water? How long does it take for the tank of fresh water to freeze? How much heat must be taken from the water after it is at freezing temperature before it is ice?

How is the salt water kept cool? As the ammonia evaporates and expands in the pipes in the salt-water tank, does the ammonia lose or gain heat? Is the salt water stirred or allowed to remain quiet? Why?

Visit the ice-storage room. How is it kept cool? What is its temperature?

What practical uses are made of ice?

EXERCISE 41

READING THE GAS METER AT HOME

Carefully examine the dials of your gas meter. Make a complete drawing of your dials similar to that shown on page 172 in the text, and carefully draw the hands just as they are on the meter. According to the directions given in the text, write the number of cubic feet indicated by the hands.

Now make three similar drawings of the dials, omitting the hands. On three successive days at the same hour, go to the gas meter and locate the exact position of the hands and draw them in the prepared dials. Write under each drawing the number of cubic feet of gas indicated.

Now find the successive differences between the numbers and see how nearly they agree. Why are they different?

Every time the gas meter is read by the company, you read it and keep a record of it to verify the company's readings. This may save your father the trouble of complaining about his gas bill.

EXERCISE 42

[*Demonstration by Students*]

TEST THE LAW OF LEVERS

See text, § 122

Apparatus and Material. — Yard stick or meter stick, several weights.

Balance or suspend the yard stick or meter stick

and apply weights and forces in various positions in such a way that they balance or cease to produce motion around the point of suspension. Multiply the weight by its distance from the fulcrum, and compare with the force multiplied by its distance from the fulcrum.

Use the meter stick in such a way that all three classes of levers are represented. Verify the law in each class.

If you have a lever bar of a given length, can you lift more when it is used as a lever of the second class or when it is used as a lever of the first class?

Where have you seen and used levers of the third class? When are they used?

Give several examples of all of the three classes of levers in practical use.

Make a drawing of the levers used in this experiment.

EXERCISE 43

[*Demonstration by Students*]

FIND THE MECHANICAL ADVANTAGE OF AN INCLINED PLANE

Apparatus. — See text, page 186. (If you haven't one, make it and borrow a spring balance.)

Follow directions given in the text, § 124. Use planes of different heights.

Why is a plank used to roll barrels into a wagon?

In building roads, why are the grades made gradual?

Make a drawing of an inclined plane.

EXERCISE 44

[*Demonstration by Students*]

FIND THE MECHANICAL ADVANTAGE OF PULLEYS USED IN VARIOUS COMBINATIONS

Apparatus and Material. — Pulleys, small rope or cord, spring balance, and weights.

Set up your pulleys as shown in the text, § 127. Attach the spring balance to the cord indicated by the letter "F." The spring balance will measure the force applied.

Verify all of the statements made in the text concerning a single fixed pulley and single movable pulley.

Set up pulleys for block and tackle combination in two ways. First, to give an even number for the mechanical advantage, as 2, 4, or 6. Second, to give an odd number for the mechanical advantage, as 3, 5, or 7.

Make a drawing of each combination to show the difference.

Of what practical use is the pulley?

EXERCISE 45

EXAMINATION OF PRACTICAL MACHINES

Examine carefully and make a drawing of one of the following machines: egg beater, clothes wringer, washing machine, meat grinder, bicycle, skates, etc.

Label all of the different kinds of levers used. By measurement, determine the mechanical advantage of each. What is the purpose of cogwheels, belts, and chains?

How have these machines affected the lives of your parents? When did some of them come into use?

How do these and other machines affect the time which you spend in school?

EXERCISE 46

WATER WHEELS

If there are any water wheels for running machinery near your home, visit them and make a drawing of one, and explain its operation.

Or examine carefully and make a drawing of a water motor on a washing machine and explain its operation.

Or make a small water wheel that will run in the proper kind of a stream or under a spigot. Make a drawing of this and explain how the water causes it to turn.

Of what practical use are water wheels?

EXERCISE 47

VALUE OF A STREAM OF WATER

See text, § 136

Visit a creek or river and determine how much water flows past any one point in a second by measuring the width of the stream, the average depth, and the speed of the flow of water by placing a float near the middle of the stream and measuring the distance it flows per second.

Could a dam four or six feet high be built in the stream? How many pounds or kilograms of water

would pass over the dam per second? How much work would the water do per second? (Use whatever height the dam could be built.)

How much power could be developed? What kind of water wheel would give the most power?

Would it be profitable to build such a dam and install a water wheel to develop electricity for your home or your village, or for a city?

EXERCISE 48

WINDMILLS

Make a toy windmill of wood or paper and find how the wind makes it turn.

Make a drawing of it and indicate with arrows where the air strikes to make it turn and the direction of rotation. Explain why it turns.

Is there any similarity in the way a water wheel is turned by water and the way a windmill is turned by the wind? Explain.

What practical use is made of windmills?

EXERCISE 49

STEAM AND GAS ENGINES

Visit a steam or gas engine. Examine all of its parts and workings carefully. Make a drawing of it and label all of the parts. Explain the source of its power.

What is the purpose of heavy wheels on stationary

engines? Why are they not needed on automobile engines?

What are the two classes of steam engines? Which class is most often used on ocean liners?

Where is the fire that produces the energy to run a gas engine?

What practical use is made of engines? Who invented the steam engine? When? When did the gas engine come into use?

EXERCISE 50

THE SIPHON

Apparatus and Material. — U-shaped glass tube or a rubber tube, two vessels, water.

Fill a U-shaped glass tube or a rubber tube full of water and close both ends with your fingers. Put one end into a vessel of water and the other end into an empty vessel lower down than the full vessel and remove both fingers. The end of the tube in the empty vessel should be lower than the top of the water in the full vessel. If the water does not flow, try again.

Can you start the flow of water in any other way?

What causes the water to flow? Is there anything producing pressure on the water? Explain.

Make a drawing of your apparatus.

What practical use is made of the siphon?

EXERCISE 51

LIQUID PUMPS

Make a common lift pump or force pump that will pump water.

Make a drawing of your pump.

Explain how the water gets up to the lower valve. Explain how it is forced from the lower valve to the pump spout.

At least how near must the lower valve of a pump be to the water in a well? Why? When and by whom was this discovered? (See text, page 151.)

Why do many force pumps have air domes?

Of what practical use are liquid pumps?

EXERCISE 52

GAS PUMPS

Examine a bicycle pump or hand pump for an automobile. Make a drawing of it.

Where does the air enter? Where does the air come out? How does the air pass the plunger or piston?

Take the pump apart and examine the valves, if any, and piston. Is it a force pump or an exhaust pump? How do they differ? What is the practical use of each?

What kinds of air pumps are on locomotives and street cars? What is their use?

Visit some large store to see pneumatic dispatch tubes in use. Do the leather pockets fit air-tight in the brass tubes? Why? What kinds of air pumps are used in the operation of these tubes?

EXERCISE 53

WATER SUPPLY

NOTE. — Make a careful study of your home water supply.

Visit and examine carefully the source from which the water comes.

Is it surface or underground water? Have it tested to find if it contains any chemicals or bacteria that are dangerous. If it does, how can they be removed?

Visit your city filtering plant. How often is the water tested before filtering? Why? How often is the filtered water tested? Why?

What chemicals are added to purify the water? What do the filters take out of the water?

Of what are the filters made? Make a drawing of the cross-section of a filter.

How does the water get from the filters to your home?

Should any filth be thrown into the city reservoirs? Why not?

What can you do to get purer water and a better system for supplying it?

EXERCISE 54

PURE WATER AND HEALTH

Send to the Departments of Health or Boards of Health of several cities for statistics showing kinds of diseases and number of cases of each, covering several years of time before they had filtered water and also covering the time since they have had filtered water.

Examine these carefully, taking one disease at a time. Find the number of cases before and after the water was filtered. What diseases were affected by filtered water?

If filtered water caused a reduction in the annual cases of diseases, find how many. Figure the average cost of each case (see text, page 5), and multiply this number by the number of cases.

From the Department of City Water, learn the extra annual cost of filtered water over the cost of unfiltered water. Compare this with the cost of diseases due to unfiltered water.

Compare the cost of one case of typhoid fever with your annual cost of filtered water.

Does it pay to have filtered water?

EXERCISE 55

[*Demonstration by Students*]

LAW OF MAGNETS

Apparatus and Material. — Two bar magnets. Suspend one of the magnets as shown on page 239 in the text.

With the end of a bar magnet approach slowly the side of one end of the suspended magnet. Do not get near enough to touch. Carefully observe the first motion of the suspended magnet and record the action.

Now approach the other end of the suspended magnet with the same end of the one in your hand. Observe the first motion and record.

Now reverse the magnet in your hand and repeat the operation. Record results. Compare these results with the first two trials.

Do your results agree with the last sentence in § 163 of the textbook?

Make a drawing of your apparatus and indicate with arrows the direction of motion.

How does this property of magnets compare with the gravity of the earth?

EXERCISE 56

[*Demonstration by Students*]

MAGNETIC FIELDS AND MAGNETIZING STEEL

Apparatus and Material. — Two bar magnets, sheet of paper, iron filings, piece of steel (such as a knife blade), piece of soft iron.

Place a sheet of paper over a magnet and sprinkle on it some iron filings. Make a drawing of the field.

Place opposite poles of two bar magnets about one inch apart, cover them with a sheet of paper, and sprinkle with iron filings. Make a drawing.

Now place two like poles about one inch part, cover with paper, and sprinkle with iron filings. Make a drawing. How does this drawing differ from the previous one?

According to directions in § 168 of the text, magnetize your knife blade or other piece of steel. Magnetize a piece of soft iron. What is the difference

between the magnetism of soft iron and the magnetism of steel?

So far as magnetism is concerned, does this property of soft iron and steel have any practical use? What?

EXERCISE 57

[*Demonstration by Students*]

PRODUCING ELECTRICITY BY FRICTION

The best results are obtained on a dry day when the air is dry.

Apparatus and Material. — Several silk threads, dry pith balls obtained from elder or cornstalks, a glass rod, piece of silk.

Suspend on silk threads several dry pith balls. Rub the glass rod with silk cloth and touch the suspended pith balls in several places on the glass rod, but do not let the pith balls touch any part of your body or any object except the glass rod. Remove the glass rod from the balls and rub again with silk.

Now slowly approach the pith balls with the charged glass rod. How do they act? Why?

Glass rubbed with silk has a positive charge, the negative charge is on the silk. What kind of charge did you give the pith balls when you touched them with the glass rod?

Rub again the glass rod with the silk and slowly approach the charged pith balls with the silk cloth. Explain what happens. (Carefully read § 171 in the text.)

EXERCISE 58

ELECTRIC CELL

Apparatus and Material. — Set up the apparatus as shown on page 252 of the text, using the same chemicals and metals.

Disconnect the wire from one of the poles and observe carefully what happens around the zinc plate. What happens to the copper plate?

Connect the two poles with a copper wire and observe the action around the plates. What causes the bubbles coming from the copper? (If any bubbles come from the zinc plate, the zinc is not pure.)

Have some part of the wire connecting the two poles in a north and south direction, and hold on this part of the wire a very small compass. How does it affect the compass needle? Carefully remove the bubbles from the copper plate by rubbing a stick down on it on both sides, at the same time watching the compass. What effect did it have? How is the compass affected while bubbles are again collecting on the copper? (A weak current going over the wire permits the compass to point almost north, while a strong current causes the compass needle to swing to the east or west, depending on whether it is above or below the wire.)

What name is given to the effect produced on the current by the bubbles on the copper plate?

Make a drawing of the cell, showing the poles connected and indicate the direction of the current.

EXERCISE 59

[*Demonstration*]

POLARIZATION, ITS EFFECT AND REMOVAL

Use a large simple cell and by means of a large (or lecture-table) galvanometer properly connected with the two poles of the cell show how polarization reduces the current.

Show how a few drops of bichromate of potash will for a time remove polarization.

Show the structure of the Daniell cell, the gravity cell, or any other cell which does not polarize. Connect it properly with a galvanometer to show that the current is constant. (A high resistance box must be used in series with the galvanometer to avoid excessive deflection.)

Also show that a dry cell polarizes in a very short time, if in continuous use.

EXERCISE 60

THE DRY CELL

Apparatus. — Have one dry cell sawed into two equal parts as shown on page 257.

Carefully examine a dry cell and make a drawing of it. Label all the parts and tell what each part is for. What chemicals are used in it? What is the use of each?

Indicate by the plus and minus signs which poles are positive and which are negative. What practical uses are made of dry cells?

After they are once too weak to ring an electric bell, can they be recharged? How?

EXERCISE 61

[*Demonstration by Students*]

ELECTROMAGNETS

Apparatus. — Several electric cells which give a constant current, a helix, several electromagnets or coils of which electromagnets can be made, a magnet, and an iron rod.

Connect the helix with one or more cells in series and point it at a compass as shown on page 260, or at a suspended magnet, and observe the first motion of the compass as the helix approaches one end of it. Determine which is the north and south pole of the helix.

Now slip an iron rod into the helix and repeat the experiment. What effect does the iron have?

Make a drawing of this apparatus.

Connect two or more electric cells with electromagnets as shown on page 261. Determine which are north and south poles. Find the lifting capacity.

Make a drawing.

What practical use is made of electromagnets?

EXERCISE 62

PRACTICAL USE OF ELECTROMAGNETS AND ELECTRIC CELLS

Apparatus. — Electric bells, telegraphic instruments, insulated wire, and electric cells (wet or dry).

1. Make a drawing of an electric bell and find how the current gets through it to produce the vibrations of the hammer. To do this it will be necessary to connect it properly with an electric cell to make it operate. Use the push button to make the bell ring.
2. Make a drawing of the bell, push button, and cell to show how they are connected.
3. If there is anything wrong with your electric door bell at home, find the trouble and repair it. (A drawing of the way the bell is connected at home deserves more credit than a drawing made of the apparatus at school.)
4. For those who prefer it, the telegraphic instruments may be used in place of the electric bell.

EXERCISE 63

STUDY OF LAMPS

There are three kinds of electric lamps on the market, namely, the carbon, tungsten, and nitrogen bulb. The carbon and tungsten bulbs have no gas in them. The nitrogen bulb is filled with nitrogen gas. The power (number of watts) used by each lamp per hour is indicated on the bulbs when they are purchased. Electric power is usually paid for at the rate of nine to ten cents per kilowatt (1000 watts).

The candle power of the carbon lamp is about one-third of the number of watts indicated on the bulb, the candle power of the tungsten is about four-fifths, and the candle power of the nitrogen-filled bulbs is about eight-fifths of the number of watts used per hour. The average time that a good bulb of any of the three kinds of lamps will burn is 1000 hours. Electric companies usually furnish carbon lamps free of charge to the consumers.

How many watt hours are required to produce 120 candles of light in a room, if carbon lamps are used? If tungsten lamps are used? If nitrogen lamps are used?

By the time the lamps burn out, they will have burned 1000 hours. If a lamp consumed only one watt per hour, it would consume one kilowatt in 1000 hours or nine to ten cents worth of electricity. What would be the cost of a lamp that consumed 15 watts per hour, while burning 1000 hours?

1. What would be the cost of 120 candles of light in a room for 1000 hours, if carbon lamps are used? Cost of carbon lamps in your town = ?

2. Cost if tungsten lamps are used? Cost of tungsten lamps in your town = ?

3. Cost if nitrogen lamps are used? Cost of nitrogen lamps in your town = ?

4. Cost of light plus lamps = ? (Carbon lamps.)

5. Cost of light plus lamps = ? (Tungsten lamps.)

6. Cost of light plus lamps = ? (Nitrogen lamps.)

Is it cheaper to buy tungsten and nitrogen lamps than to have carbon lamps given to you?

Electric lighting generators can now be purchased

for homes in the country at a very small cost and the fuel consumed to generate the electricity costs about three to four cents per kilowatt hour.

The candle power of various other kinds of lamps — natural gas lamps, artificial gas lamps, acetylene gas lamps, gasoline lamps, and carbon oil lamps — can be learned from the manufacturer and often from the agent handling them. If you use any of these kinds of lights in your home, find out how much fuel is consumed per hour to produce 120 candles of light. Then find the cost per hour. Then for 1000 hours.

To find how much fuel is used, turn on enough lamps to produce 120 candles of light, then watch the gas meter for an hour and find the cost of the gas consumed, and multiply by 1000.

If fuel other than natural gas is used, find how much it costs to produce 120 candles of light for one hour or 30 candles of light for four hours, by keeping a record of the chemicals consumed; then multiply this cost by 1000 to get the cost of 120 candles of light for 1000 hours.

Now compare the cost of light produced by electricity with the cost of the same quantity of light produced by burning gas or other fuels.

Could you improve your lighting system and at the same time reduce the cost?

EXERCISE 64

LENSES, EYE GLASSES, MAGNIFIERS

Carefully examine lenses of optical instruments such as opera or field glasses, small telescopes, reading lenses, and pocket magnifying lenses. Make draw-

ings of all of the different kinds that you find and label them. (See page 273 in text.)

Examine the lenses of eye-glasses and determine what shape they have. How do the lenses differ for a person who is farsighted from the lenses for a person who is nearsighted?

Of what are lenses made? How do they affect light? (Hold a lens in direct sunlight to see.) Would a piece of glass with flat surfaces have the same effect on light as if the surfaces were curved?

EXERCISE 65

CAMERAS

Apparatus — Sheet of paper with a pinhole, cardboard, simple lenses, and a camera.

Form an image of a lighted candle, window, or some other light object by means of a pinhole in a sheet of paper and another paper or cardboard held back of the pinhole as shown on page 273 in the text.

Now remove the sheet of paper containing a pinhole and put in its place a simple lens. Compare the image with the one formed by the pinhole.

To get a good image take the lens to a window and throw on the cardboard an image of some object outside. How does the size of this image compare with the size of the object? Is the image inverted or erect?

Now examine your camera and see what kind of an image it forms. Ask your teacher to explain how to use the various parts of your camera in order to get a good picture.

EXERCISE 66

[*Demonstration by Students*]

PRODUCTION OF A RAINBOW

Material. — Two triangular glass prisms.

Hold a triangular glass prism in direct sunlight, turning it until the colors of the rainbow are seen in a direction opposite that of the sun. Two sets of colors can be produced at one time if the prism is held in proper position.

Make a drawing of the colored spot and have the colors arranged in the same order in which they are made by the prism.

Now hold another prism against the first one and see what happens to the colored lights. (If the second prism is held in the right position, the colored lights made by the first prism will be thrown together and form white light again.)

At home, cause a rainbow to be formed with a sprinkling hose or other means of making spray in the sunshine. Where is this formed rainbow with respect to you and the sun? Can it be seen from one side or does it seem as though you are facing the center of the circle of which the rainbow is a part? Can two persons see the same rainbow? Why?

Why are natural rainbows not seen during mornings?

EXERCISE 67

EXAMINATION OF AN EYE

Material. — Obtain from a butcher or elsewhere the eye of some large animal.

Examine the eye carefully. Make a drawing and label the parts as seen from the outside.

Carefully cut through the cornea, the front part of the eye, and examine the aqueous humor. Find the muscle called the iris. Also the pupil. Carefully remove the crystalline lens and examine it. What liquid is back of the lens? What is the use of all these parts?

Find the optic nerve. What is its use?

What is the difference between the eye examined and your eyes?

Compare the eye and the camera.

EXERCISE 68

LIGHT AND HEALTH

What is the natural color of the leaves of most plants that you have seen?

Do leaves near the base of the tree where light is cut off have the natural color that they would have if they were in the sunshine all day? Pick up a board that has been lying on the grass for a week or more. What color is the grass under it? Why do most plants not grow well on the shaded side of a house?

Compare the color and physical appearance of people who are indoors all the time and do not take any exercise in the open air and sunshine with the

color and physical appearance of those who take exercise or work in the open air and sunshine.

Does your schoolroom and do the rooms at home have windows large enough to let in sufficient light? (If there are no obstructions outside that reduce the amount of light coming through the windows, the area of the windows should be about one-fourth the area of the floor space.)

Compare the windows of modern factories with those of factories built many years ago. Why has this change been made?

EXERCISE 69

HOW LAMPS MAKE LIGHT

Apparatus. — A candle, matches, gas lamp or oil lamp.

Light the candle and examine the flame carefully.

Can you see an area around and above the wick which does not give any light? What causes this?

Can you notice any other distinct parts of the flame?

Make a drawing of the flame and label the parts which you can find.

How does a candle make light?

Carefully examine the flame of a gas lamp, gas burner, or the flame of an oil lamp.

Make a drawing of the flame and label it to show the parts.

How does an electric lamp make light?

How does a firefly or "lightning bug" make light?

EXERCISE 70

PRODUCTION OF SOUND

Apparatus and Material. — A ruler, vise (if convenient), tuning fork, vessel of water, and a stringed instrument.

Fasten the ruler in the vise or hold it firmly on the edge of your desk, with one-half or more of the ruler extending over the desk. Snap the end of the ruler. Does it produce a sound? Does it vibrate?

Strike a tuning fork so that it gives out a sound, and while it is sounding touch the ends of the prongs to the surface of water as shown on page 295. What happens? Is this evidence that the fork is vibrating? Make a drawing of what you saw.

Pick the string of a violin or any stringed instrument. Can you see that it is vibrating? While the string is giving a sound, slowly approach the string with your finger nail until it merely touches. Do you feel any vibrating motion?

What is the cause of sound? How is it carried to your ear? How fast does it travel?

EXERCISE 71

[*Demonstration*]

REINFORCING SOUND

Apparatus. — Tuning fork, violin (if convenient).

Cause the tuning fork to vibrate and hold it firmly on the desk, table, or box. (Have the fork in a vertical position, handle down, prongs upward.)

Cause the fork to vibrate, and while holding it in your hand have the students indicate the instant they

cease to hear it. At the same instant hold the fork on a desk or preferably on a violin box or other stringed instrument with a hollow resonance chamber. This gives an idea of the use of the hollow resonator.

For Students. — What is the use of the sounding board in a piano? What effect do the large pipes of a pipe organ have on a tone?

Why is it better for the audience to have a large dome-shaped object back of the orchestra? Would a steep hill serve the same purpose as this dome? How?

Notice the shape or angle of the wall on either side of the position where a speaker stands in a large auditorium What is the purpose of this?

Find by experiment how far you must be from an object, building, or hill to get a good echo, that is, to hear a spoken word come back to you as though some one else said it. Measure the distance and explain why it had to be that number of feet.

EXERCISE 72

THE HUMAN EAR

Carefully examine the model of a human ear. If you have no such model, examine the diagram in the text, page 302.

Make a drawing of the ear as shown by the model or diagram and label all the parts.

State the use of each part.

Why is a blow with the open hand on the external ear dangerous? What causes earache? How do colds affect the ear? What is the use of wax in the auditory canal? If this wax hardens, how can it be removed?

EXERCISE 73

EXAMINATION OF SOIL

Apparatus and Material. — Some garden soil, sheet of paper, magnifying glass.

Notice carefully the soil from which you have taken your sample.

Place about ten grams of your sample of soil on a sheet of paper.

Examine it with a magnifying glass. Does it seem to be compact or are there many spaces for air?

Spread out your soil and with the aid of your glass pick out what seem to be particles of plants in the process of decay; place these on one side.

Pick out small stones, even as small as sand grains, and keep them separate from the plant matter.

Is there any water in your soil? How can you tell?

Compare your soil with the soil of other students.

Is it dangerous or healthy to work with soil in the manner in which gardeners and farmers do? Are farmers afraid to get soil on their hands?

Would you rather live in a house with rich soil in the yard covered with growing grass, flowers, and shrubs, than to live in a house with a yard covered with concrete or brick? Why?

EXERCISE 74

[*Demonstration by Students*]

EFFECT OF ACIDS ON ROCK

Apparatus and Material. — Nine one-half liter beakers or large-mouthed bottles, all made of glass; nitric acid, sulphuric acid, hydrochloric acid, limestone or marble, sandstone, and granite or other composite stone.

Place 5 grams of crushed limestone in each of three different beakers, 5 grams of sandstone in three other beakers, and 5 grams of granite in the remaining three. Pour 400 c.c. of water into each beaker. Set the beakers in three groups of three each, those containing limestone together, those containing sandstone together, and the others together.

To one of the beakers containing limestone add 4 c.c. of nitric acid, to another add 4 c.c. of sulphuric acid, and to the last one add 4 c.c. of hydrochloric acid. Label them to indicate which acid was added.

Add the same quantity of acid to each beaker in the other two groups and label them.

Observe carefully what the immediate action is and record it.

Set the beakers where they will not be disturbed and examine them every day to find what has happened.

After a week has passed answer the following questions: (1) Which kind of stone is affected most by the three acids? (2) Which is affected most rapidly? (3) Which acid has the greatest effect on limestone? (4) On sandstone? (5) On granite?

If ground-water contained one or more of these acids, how would it affect rock?

Do you know any particular place where rock has been removed by the action of chemicals in ground-water?

Do you know of any other way in which rock is broken up naturally?

EXERCISE 75

[*Demonstration by Students*]

WATER-HOLDING CAPACITY OF SOILS

Apparatus. — Prepare apparatus similar to that shown on page 311 of the text. Tie up the necks of the bottles with cheesecloth to prevent the soil from passing out. Fill the bottles almost full of the kind of material indicated on them. Pour into each bottle enough water to make the material moist, so that just a few drops come out at the bottom.

Twenty-four hours later pour about 100 c.c. of water into each bottle. Three hours later measure the water that has gone through the bottles.

Now let the apparatus stand for a few days until the material in each bottle is comparatively dry. Then fill with water the glasses shown in the box and keep them full for several days. Every day examine the top part of the material in each bottle and record its condition as to moisture.

Which of these samples of material would you say was the best soil so far as water is concerned? Why? Which material held water the longest? Why?

Which permitted water to pass through it the quickest?

When is it important for soil to let water down through it quickly? When is it important to let water up through the soil? Is there any way of preventing the escape of the moisture that comes up through the soil?

EXERCISE 76

[*Demonstration by Students*]

TESTING SOIL FOR AIR

Apparatus and Material. — A liter of each of several kinds of soil; same number of water-tight vessels with a capacity of two liters.

Place a liter of each kind of soil in a water-tight vessel. Do not pack the soil in the vessel, but pour it in loosely and shake the vessel gently so that the soil will have about the same compactness as in a field under cultivation. The soil should be in the condition of moisture that is necessary for cultivation. If it is too dry, moisten it a little; if too wet, let it dry before placing it in the vessel for the final test.

After each liter of soil is in a vessel ready for the test, measure 500 c.c. of water and very slowly pour from it into one of the vessels until the water just comes to the surface of the soil. Measure the water which is left, if any. Subtract the water left from the 500 c.c. and you will know how much you poured in. If it took more than 500 c.c. to bring the water to the surface of the soil, add the extra to the

500 c.c. Do the same for each kind of soil and record the results.

As the water goes in, the air comes out. By volume how much of each liter of soil is air?

EXERCISE 77

[*Demonstration by Students*]

TESTING SOIL FOR HUMUS

Apparatus and Material.—Several samples of soil, varying from the best to the poorest. (Always keep them separate.) An iron vessel for each sample of soil.

Spread the soils on paper separately to dry. For this purpose they may be placed in the sunshine or kept in a room.

After they are perfectly dry, weigh out 100 grams of each (500 grams may be used) and put the 100 grams of dry soil in an iron vessel. Keep the vessel and soil heated over a fire to a temperature of red heat for several hours. (This will burn out all the humus, the decaying material, and the bacteria, leaving only ash of these, which does not weigh enough to be considered here.) Now weigh the burned soil.

The loss in weight is due to the humus being burned, unless the soil was not completely dry before burning.

EXERCISE 78

CARE OF SOIL

Material. — Soil in flower pots, or a small area in a flower bed, garden, or farm.

Stir the soil with the proper tool just after a hard rain, or stir the soil in only one pot just after watering. Let the soil thus stirred be exposed to sunshine for a few days and record the condition of the soil.

Cultivate or stir some soil a few hours or a day after a rain, when the soil is not so wet as before, but yet too wet for easy working. Let this be exposed to sunshine for a few days and record its condition.

When the soil gets dry enough so that it crumbles and does not form balls when squeezed in the hand, cultivate another small area and record its condition after a few days of sunshine.

Try to cultivate soil when it is very dry and record its condition.

From the results obtained, what is the best condition of the soil for cultivation? What kind of soil gets in proper condition for cultivation most quickly?

How does it affect most plants to cultivate while the soil is wet?

Why should the soil in flower pots not be disturbed while it is wet?

Note. — Nearly every family grows plants of some kind and so it is important that all should know how to care properly for soil.

EXERCISE 79

CONSERVING SOIL MOISTURE

Apparatus and Material. — Large cube of solid white sugar, some finely powdered sugar (the kind that is light, almost like flour), a saucer, water; two flower pots of the same size, some soil in condition for cultivation, and some very dry soil or ashes.

Place the sugar in the saucer and put on top of the cube a thick layer of finely powdered sugar. Do not have any powdered sugar around the bottom of the cube of sugar.

Now occasionally pour a teaspoonful of water into the saucer. Notice how the water passes up the solid cube of sugar. What happens when the water reaches the powdered sugar? Time it to see how long it will take for the powdered sugar to become wet at the top. Supply only sufficient water to keep the bottom of the cube moist.

Do you think the same thing would happen to soil with a layer of loose, powdered soil on the top? During a dry season, where would the water come from to keep the soil moist?

Why is there a hole in the bottom of a flower pot?

Fill the two flower pots with the same amount and kind of soil dry enough to cultivate, and cover the soil in one with very fine, dry soil or ashes, and then set both of them in a vessel containing about one inch of water. Keep a record of the number of hours required for the soil to become very moist on the top of each.

After you have learned the effect of the fine, dry

soil or ashes on the one pot, set both on the ground in the sunshine for three days; then examine the soil in each one. What is the difference in the two? What is the cause?

How should the soil in flower pots be watered?

During dry weather should the soil in fields be cultivated? How? Why?

EXERCISE 80

OBSERVATION TRIP

Visit a farm to see how soil is being cultivated and cared for. Take notes.

Observe how drainage is provided for. How could it be improved?

What is there to indicate that excessive erosion is taking place? How might this erosion be prevented?

EXERCISE 81

GERMINATION

See pages 337 and 426

Plant about two dozen grains of corn and the same number of beans, peas, pumpkin seeds, etc., in soil, sawdust, or sand. Keep the soil just moist, loose, and at a temperature of about 21° C.

Every day for a week take up one seed of each kind and carefully examine it outside and inside to see what has happened. Write a description of it each day. Make drawings to aid the descriptions.

After a week or more has passed, answer the following: (1) How does the germination of corn differ from that of the other seeds? (2) How does the germination of beans differ from that of peas and pumpkin seeds? (3) What other seeds germinate like corn? Like beans?

How deep in the soil should these seeds be planted in the garden? What are all the conditions necessary for germination?

When is germination complete?

EXERCISE 82

[*Demonstration by Students*]

HOW ROOTS OF PLANTS TAKE UP WATER

Apparatus and Material. — Use a regular osmosis apparatus if you have one; if not use the apparatus described at the bottom of page 339 in the text, or use the following:

Take the animal membrane from a very small bologna sausage, wash it with soap and warm water to remove any fat. Close all openings except one. Openings can be closed by tying a string around the membrane. Fill it about half full of salt, sugar, or molasses, then slip a small glass tube, open at both ends, into the opening and tie firmly with a string. Support the glass tube in a vertical position on a ring stand with the membrane and contents immersed in a vessel of water. Wait an hour or more to see what happens, and let it stand until the water ceases to rise in the tube.

What is osmosis? Examine a root to see if water must pass through a membrane to get into the root. Where does osmosis take place in your body?

What causes the peculiar sensation when you get water in your nose while bathing?

EXERCISE 83

MOVEMENT OF SAP UP THE STEM OF A PLANT

Apparatus and Material. — A few twigs a foot or more in length and a vessel of eosin solution or ink, red or black.

Place the larger end of each twig in the vessel containing the solution and leave them there for a few hours, if late in the spring. If the buds are dormant, leave them in the solution for a day or more.

Remove one of the twigs and split it lengthwise. Make a drawing of the split surface and indicate which part of the twig is colored. Cut another twig crosswise and make a drawing of the cross-section showing where it is colored.

Through which part of the twig did the solution pass? What force caused it to move up the twig? When does sap move up a tree most rapidly? Why? In what part of a tree does the sap come down? When?

When sugar trees are tapped, does the sap come down the tree or up from below? Explain.

EXERCISE 84

LEAVES

Apparatus and Material. — Several kinds of leaves, and a microscope.

Make drawings of the various leaves. Label all the parts and tell the use of each part.

Of what use is the leaf to the plant? What is in the leaf that gives it a green color? What can this green colored material do? What are the conditions necessary for it to do its work?

If you have a good microscope, ask your teacher to show you some stomata.

EXERCISE 85

[*Demonstration*]

SHOWING THAT LEAVES GIVE OFF WATER

Apparatus and Material. — A potted plant that is in good growing condition, some dry material, — ashes, sawdust, or bits of paper, — and a large glass jar.

Cover the soil of the potted plant with the dry material, and then cover the whole plant with the glass jar closed tightly around the bottom to prevent the free entrance or escape of air. Leave it in this condition for twenty-four hours or more and watch for drops of water to collect on the inside of the jar.

What is the source of these drops of water?

EXERCISE 86

[*Demonstration*]

TESTING LEAVES FOR GIVING OFF OXYGEN

Apparatus and Material.— A bell jar that can be closed air-tight and has an opening at the top, a very small candle that can be supported on a wire and lowered into the bell jar from the top, and a potted plant in good growing condition.

Place the plant in the bell jar and force in sufficient carbon dioxide to extinguish the burning candle as soon as the candle is lowered into the jar. Close the top of the jar and stand it in the window for about two days. Now lower the burning candle into the jar again to see if it will be extinguished. (Several trials of this experiment may have to be made to be successful. After you are successful, repeat the experiment, except to place the jar in the dark for the same length of time as you placed it in the light.)

EXERCISE 87

FLOWERS

Apparatus and Material. — Several flowers as large, simple, and complete as possible, and perhaps a magnifying lens.

Examine the flowers carefully, make a drawing of one of them, and label all the parts.

What part of the flower produces pollen? What is the use of pollen? How does it get to the stigma?

What is the use of the pistil? Of the ovules? If

an egg cell in an ovule is not fertilized, what will happen to the ovule?

When you eat roasting ears you sometimes find grains of corn missing. What is the cause? Where is the pistil of corn? Where is the pollen produced? How can you assist the fertilization of egg cells of corn, if there are only a few stalks in your garden?

EXERCISE 88

RESULTS OF CROSS-FERTILIZATION OF FLOWERS

NOTE. — The results of this experiment can be seen in a few weeks with corn. With many plants two or more years are required.

Plant some yellow and white corn or yellow and sweet corn close together at the same time, so that they will be in bloom at the same time. In order to insure cross-fertilization, when they are in bloom shake some pollen from the yellow corn on the fresh silks of the white corn. Two days later shake some pollen dust from the white corn on the silks of the same ear on which you shook pollen from yellow corn. Treat a number of ears this way, reversing the process with some. When these ears ripen you will find a mixture of white and yellow on each ear.

Other plants can be cross-fertilized in much the same way, but the results are not noticeable until new flowers or new fruit are grown from the seeds produced by cross-fertilization.

EXERCISE 89

PRODUCTION OF PLANTS BY ROOTS AND CUTTINGS

NOTE. — Roots do not have buds. Stems have buds.

Apparatus and Material. — A sweet potato, a white potato, some sections of a small grapevine, each containing three buds, and some twigs of yellow willow, both kinds in the dormant state; a place for planting.

Examine the sweet potato. Is it a root or a stem? Plant it in soil where it will have moisture, air, and a temperature from 21° C. to 25° C. Examine it every few days and record what you find each time.

Examine the white or Irish potato. Is it a root or a stem? Plant it in the same conditions as the sweet potato. Examine every three days. From which part does the growth start?

Compare the growth of the white potato with that of the sweet potato.

Plant the sections of grapevine and twigs of yellow willow vertically, with two buds in the ground. Examine them every three days and record what you find. Do the roots come on the grapevine in a definite position? Do they on the willow?

Name as many plants as you can that are propagated by roots and cuttings.

EXERCISE 90

PRODUCTION OF PLANTS BY GRAFTING AND BUDDING

What kinds of trees are largely propagated by grafting and budding?

Get some twigs and limbs of one or more kinds of such trees and make a graft. Prepare a bud and set it in position. Make a drawing of the parts in both cases and also a drawing of the finished product.

What is the very important thing to be observed in setting the scion and bud in position?

When are trees grafted and budded? What is the purpose of grafting and budding? How are seedless fruit trees propagated?

EXERCISE 91

TRANSPLANTING PLANTS

Apparatus and Material. — Garden vegetables; a place for planting; young trees for transplanting.

What garden vegetables can be transplanted? When? What advantage is gained by transplanting?

In transplanting garden vegetables how much soil should be left on the roots? Why?

Transplant some garden vegetables as follows: Pull up the plants carefully in order not to lose any roots. (The soil should be in proper condition for cultivation.) Plant two rows of four plants each. For the first row keep as much soil on the roots as possible. For the second row shake all the soil from

the roots of the plants. Planting should be done in the evening.

For the first plant in each row make a hole with your finger, pour 100 c.c. of water in the hole, place the roots of the plant in the hole, and press the soil firmly against the roots. For the second one, make a hole, insert the roots, press the soil firmly against the roots, and now pour 100 c.c. of water at the base of each plant. Plant the third one of each row the same as you did the second, but do not add any water. Plant the fourth without pressing the soil firmly against the roots and add water.

Mark the plants and record how each one was planted. Observe them daily and record their progress of growth for a week.

Which wilted the most? Which the least? On which did most leaves die? Which one was in best growing condition at the end of a week?

What is the best method of transplanting garden vegetables?

Transplant some shade trees or fruit trees according to directions given in the text, page 357, and watch for results.

EXERCISE 92

EXAMINATION OF SHADE TREES OR FOREST TREES

Examine closely the trees in your yard. What kind are they? Is there any white substance which falls from the leaves? Do they send roots into sewers, wells, or cisterns?

Are there any injuries or decayed spots around the base that should be cut out, disinfected with formaldehyde, and filled with cement? Any decayed, broken, or dead limbs in them? If so, remove them by proper amputation.

Are there any dangerous diseases or insects affecting your trees? What kind? (See index.)

Give several reasons for having shade trees.

EXERCISE 93

VISIT TO A POND OR SOME STAGNANT WATER TO FIND ALGÆ

Visit a pond, taking along a tin can or other vessel to carry material that may be found.

Look carefully along the edge for any green material that may be floating on the surface or on sticks or logs just under the water's surface. (In some places you may find a green material which is not of the algæ group floating on the water. One of the smallest flowering plants, duckweed, grows on such water. It has two or three leaves about 0.4 centimeters in diameter on the water's surface and a fine thread for a root suspended beneath the leaves. The roots are 5 to 8 centimeters long.)

Find a green material composed of very fine and long threads without any leaves or enlarged parts. If you find some that seems to be floating, look closely and you will find bubbles of gas distributed through it.

What gas is in these bubbles? What makes the plant float? Stir it gently with a stick to remove

the bubbles and then let it loose to see if it will float. Explain the result.

Where do these plants get their food? Are they injurious or beneficial? Why?

Take some of these plants to school and have your teacher show you how they appear through a microscope.

How does this plant reproduce? Would it die if the pond should dry up? Why? If you made a new pond, how would this plant get into it?

EXERCISE 94

[*Demonstration*]

OBSERVING YEAST PLANTS

Apparatus and Material. — One-fourth teaspoonful of sugar, 100 c.c. of water, small piece of dry yeast or, better still, a cake of soft yeast.

Dissolve the sugar in the water and mix with this a very small piece of the dry yeast or of soft yeast. Let the mixture stand for a few hours at room temperature.

Without stirring the mixture, get a drop of the almost clear liquid and place a small part of it on a microscope slide. Show it first with low power to get an idea of how numerous the plants are, then turn on the high power to observe the shape of the plants and the method of growth.

In the liquid under observation there may be a few carbon dioxide bubbles and also a few particles of

starch from the yeast cake. These can easily be distinguished from the yeast plants.

What are the necessary conditions for the growth of these plants? Of what commercial value are they?

EXERCISE 95

MUSHROOMS

Look around your house, in the front and back yard, around the barn, under trees along the street, in the parks, and in the woods for umbrella-shaped and almost cream-colored growths a few inches high. The poisonous ones of these are called toadstools and the others mushrooms. Do not eat any unless you are sure they are not poisonous.

Observe carefully where they grow. Is the soil rich or poor? Do they grow in soil? Carefully remove the soil from the base of a large one and find its roots. What color are the roots?

Examine the under side of the mushroom cap. What grows on the folds? What is their use? What is the purpose of this part of the mushroom?

Dig up some soil or material in which mushrooms grow, take home a good quantity of it, and after putting into it some of the roots of a mushroom, keep it moist and at a temperature of 21° C. to 25° C. in a dark place most of the time, in order to see how long it will take for a mushroom to appear.

After a few weeks have passed, observe it every day. When a mushroom is noticed just coming through the surface, keep a record of the number of hours it takes to grow to full size.

Is the idea that mushrooms spring up in a night founded on fact? Explain.

Do mushrooms and toadstools serve any useful purpose? What?

EXERCISE 96

MOLDS

To grow some mold, follow the directions given in § 254 of the text.

After the mold becomes very noticeable on the bread, examine it with a magnifying glass or microscope.

Find some other kinds of mold and examine with the aid of magnifiers.

What do they live upon? What are their necessary conditions for growth? How do they reproduce? Compare them with mushrooms.

If bread that you want to eat has mold on it, how much should be cut away? Is moldy cheese good to eat?

What very useful purposes do molds serve?

EXERCISE 97

APPLE RUST

Examine apple leaves carefully for yellow spots of apple rust.

Make drawings of several leaves affected by the rust to show the number and size of the spots.

Examine the limbs of cedar trees for greenish-brown knots. What are these? What will the big knots which you find one summer do the next spring?

What relation exists between these knots on the cedar trees and the yellow spots of apple leaves?

How do the spores get from one tree to another?

What can be done to prevent the destruction of apples by the apple rust?

EXERCISE 98

BROWN ROT

Examine plum, peach, and cherry trees between late fall and early spring for shriveled, dry fruit hanging on the limbs. These dried fruits may also be found during late summer.

Place several of these dried fruits in the bottom of a vessel and add sufficient water to cover about half of each, the other half being exposed to the air. Keep them at living-room temperature for several weeks. After the end of the first week, examine every few days to see if spots of brownish powder appear on them. Examine this powder under a microscope. Does it look like small seeds?

This brownish powder consists of spores to be carried away by the air to young fruit.

What time of the year would these spores develop if the dried fruits were left on the trees or on the ground?

What is the remedy for this disease of fruit?

EXERCISE 99

PEAR BLIGHT

Visit a pear orchard in late July or August for indications of the disease, pear blight, indicated by dead twigs in various parts of the trees.

Examine the trunks of the trees for hold-over cankers — diseased-looking spots.

What remedy can be used during the summer?

What remedy can be used to remove the cankers?

EXERCISE 100

SCALE INSECTS

Examine the twigs and fruit of all kinds of fruit trees for scales; some are round and about the size of pinheads; some have the shape of an oyster shell. The oyster-shell scale may be found on orange trees.

Make drawings of the San José scale and the oyster-shell scale, as they appear from a top view.

Carefully remove the shell and examine the living insect under it with a magnifier; make a drawing of it.

How do they reproduce? How rapidly? How destructive are these insects?

What remedy can be used to destroy them? When can it be used?

EXERCISE 101

EATING INSECTS

Find some apples or pears with wormholes. Cut them open to find the "worms." These "worms" are codling moth larvæ — the eating stage of the moth.

Make a drawing of an apple cut open to show the effect of a larva.

How do these larvæ in fruit affect its market value? How do they affect the quantity of the fruit crop?

Examine carefully the bark of old apple trees to find a very small bunch of whitish wool, a cocoon, with a brown object under it next to the wood. What is this brown object? Is it dead? When does the egg-laying adult moth appear? How and when does it travel?

What is the best means of destroying this moth? When?

What other insects can be killed in the same way?

EXERCISE 102

[*Demonstration*]

PROTOZOA

Apparatus and Material. — A large jar, some hay, grass, or lettuce, and a microscope.

Fill the jar about two-thirds full of water, put into this some hay, grass, or lettuce, and let it stand, with the top open, for about four days at living-room temperature.

At the end of this time, examine with a microscope a drop of the scum on top of the water.

Let the students see the animals and explain their origin.

EXERCISE 103

EARTHWORM

Dig up some earthworms. How near the surface can they be found? How deep do they go? How do they make their holes in the ground?

What do they eat? Prove your answer by observation.

Pick up one. Is it rough or slimy? How does it breathe?

When do earthworms travel? Why do they come to the surface during rain? Why do they often die on streets and sidewalks, even though not injured?

What value are they to the farmer? What injury?

How do they reproduce?

EXERCISE 104

CRAYFISH

Go to some stream, pond, swampy place, or to a spring on a hillside, and find some crayfish or crawfish; or, better still, go to all of these places for crawfish.

Where do you find them in streams? In ponds? In swamps?

How do they move when frightened? How do they move while seeking food?

What do they eat? How do they hold their food?

What value are they to man?

Make a drawing and label the principal parts.

How do they reproduce? What is the difference between a soft-shelled and a hard-shelled crawfish?

EXERCISE 105

AMPHIBIANS

Go to a pond or swamp and find frogs, tadpoles, and eggs. (Eggs of both frogs and toads are found in the early spring. The tadpoles of toads are found shortly after and until midsummer.)

How do tadpoles move? How do they breathe? How do adult frogs and toads breathe? When do they make this change?

What do tadpoles eat? What do adult frogs and toads eat?

What value are frogs and toads to man? What difference is there between the habits of an adult frog and a toad? Which is the more useful?

Make drawings of real tadpoles and adult amphibians.

How do they reproduce?

EXERCISE 106

REPTILES

Take a trip through fields, woods, and along streams to find snakes and turtles in their native condition, or go to a "zoo."

What time of the year may these animals be found? Why not at other times?

In what kinds of places do they live? Do they ever come near houses?

How do they move? With what speed? Watch the movements of a small snake to see how it keeps from sliding backwards. After you kill it, rub your fingers both ways along the under surface. What difference do you find?

What do snakes eat? How do they eat? Are they of any value to farmers? What?

What do turtles eat? How? Do they have teeth? Are turtles of any value?

How do snakes and turtles reproduce?

How do they differ from amphibians? How are they similar to birds?

EXERCISE 107

BIRDS

By careful observation and reference to books on birds, make a detailed study of some particular bird, domesticated or wild.

What are its habits? Name everything that it eats. Describe its characteristic movements while walking or flying. Can it swim?

Does it have teeth? If no teeth, what takes the place of teeth? How does it breathe?

Examine its feet. In what way are they like the skin of a reptile?

Compare its eggs with those of reptiles.

How does it differ from reptiles in the care of its eggs?

How, when, and how often does it reproduce?

What is its value to man?

EXERCISE 108

MAMMALS

Make a careful study of some particular mammal, domesticated or wild.

What is its origin? Habitat? Habits? Food? Relation to other animals? Use to man?

How do mammals reproduce?

How may domesticated animals be improved?

EXERCISE 109

HOUSE FLY OR TYPHOID FLY

Imprison several house flies in something large enough to hold a bit of liquid food or water and dry food, and some decaying material; a small quantity of manure will do. Keep a complete record.

Watch when they deposit eggs. When do the larvæ or "maggots" appear? How long are they in the larval state? How large are the adult larvæ? What do the larvæ eat? What do the larvæ do when they become full grown? How long are they in the pupal state? Give color and size of pupæ. What comes out of the pupa?

How many legs, wings, and eyes does the adult fly have?

Does a fly grow any larger after it comes from its pupa? What does it eat?

What good do flies do? What injury?

Should flies be destroyed? Why? What is the most effective method?

EXERCISE 110

MOSQUITOES

Imprison some mosquitoes and put them in a vessel of water slightly stagnant without a scum; or watch a rain barrel or other vessel of water standing outside the house, in order to learn their life history.

Write their complete life history as you find it by observation.

How large are the larvæ? What do the larvæ eat?

Are they of any value to man? Any injury? What?

Which of the three kinds are in your vicinity?

What methods can be used to kill them? In what stage of their life history are they most easily killed?

How does oil on the surface of water kill them?

EXERCISE 111

EARTH'S NEIGHBORS

Look in your almanacs to find what planets are now visible and in what part of the sky they may be found and at what time. Observe them for several nights in order to distinguish them from other stars.

How far away is the moon? Does it always keep the same side toward us? What is a lunar month?

Does the moon always appear on the eastern horizon at the same time? Does the sun? How much later or earlier does the moon appear each day?

Keep a record of the different phases through which the moon passes from full moon to full moon. How much time is required for each phase? How much from full moon to full moon?

What causes an eclipse of the moon?

Observe the moon and some of the planets with a large telescope, if possible.

EXERCISE 112

CONSTELLATIONS

NOTE TO TEACHER. — See *A Study of the Sky* by Howe, Scribners.

Locate the North Star and draw it near the center of a large sheet of paper.

Locate the Great Dipper and draw it in the proper place with reference to the North Star already located.

The two stars of this dipper opposite the handle are called the pointers. To what do they point, if a line determined by them is drawn?

Locate the Little Dipper, of which the North Star is the end of the handle. Draw it in the proper position.

Now locate other constellations that may be visible.